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- (54) Title of the Invention: Horn-Type Speaker
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## **SPECIFICATION**

### **1. Title of the Invention**

Horn-Type Speaker

### **2. Claims**

A horn-type speaker, characterized in that the side of an acoustic tube having a prescribed length, with one end open and the other end closed, and a main speaker attached at said closed end, is provided with a canceller speaker at a location at which the higher-order resonance sound pressure is at a maximum, and at which the opposite phase is produced relative to the closed end, where [said canceller speaker] is driven in the same phase as said main speaker.

### **3. Detailed Description of the Invention**

[Field of industrial utilization]

The present invention relates to improvements to horn-type speakers, in which a speaker is situated at one end of an acoustic tube of prescribed length, referred to as a horn, and sound waves from this speaker are emitted from the other end of the acoustic tube.

[Prior art]

An example of the utilization of sound from this type of conventional acoustic tube, as presented in Figure 8, is a horn-type speaker used in order to reproduce bass sounds with good efficiency.

In this figure, 1 denotes a horn, 2 denotes a speaker unit that is attached to the close end of the horn 1. Sound produced by the speaker unit 2 emanates from the opening 1a of the horn 1.

When the shape of horn 1 has a small expansion ratio, the sound waves are reflected at the opening 1a, generating a resonance effect.

In this case, the fundamental resonance frequency  $f_1$  is defined by the formula below.

$$F_1 = C/4l$$

C: Speed of sound

l: Tube length

With horn 1, the sound waves repeatedly reflect and interfere with each other, producing standing waves, but resonance resulting from the standing waves occurs at intrinsic frequencies whereby the length of horn 1 stands in ratios of  $1/4, 3/4, 5/4, \dots$ , with respect to the wavelength.

Consequently, high-output sound pressure is obtained at these frequencies.

However, when only the above fundamental resonance frequency  $f_1$  is to be used and the bass reproduction range is to be wide, it is necessary to lower the sound pressure peaks generated by unwanted higher-order resonance indicated in Figure 9, e.g.,  $f = 3f_1, 5f_1, 7f_1, \dots$ .

For this reason, a resonator or acoustic member is situated at a location corresponding to a peak on the inner surface of the horn 1, as shown in Figure 10, thereby attenuating the higher-order resonance.

(Problems to be solved by the invention)

Higher-order resonance attenuation methods of this type have the disadvantage that the fundamental resonance frequency  $f_1$  is also attenuated, as indicated by the broken line in Figure 11.

(Object of the invention)

The present invention has the objective of obtaining flat sound pressure-frequency characteristics in the higher-order resonance frequencies, by means of attenuating specific higher order resonance, without the typical attenuation of the fundamental resonance frequency  $f_1$ .

(Gist of the invention)

The present invention relates to a means used in horn-type speakers whereby the above objectives are attained. The above objectives are attained by a means wherein the side of an acoustic tube having a prescribed length, with one end open and the other end closed, and a main speaker attached at said closed end, is provided with a canceller speaker at a location at which the higher-order resonance sound pressure is at a maximum, and at which the opposite phase is produced relative to the closed end, where [said canceller speaker] is driven in the same phase as said main speaker.

[Working examples of the invention]

Working examples of the present invention are presented below in reference to Figure 1.

The first working example is used in order to generate favorable reproduction of frequency  $f_1$  at a wavelength  $\lambda$  that is four times the length  $l$  of the horn 1, while attenuating the peak of the  $3f_1$  frequency.

In this horn-type speaker, the  $3f_1$  sound wave generated by the main speaker 4, as shown in Figure 3, has an inverted phase at a distance of  $2/3 l$  from the main speaker 4.

Specifically, in this working example, the sound pressure generated by the main speaker 4 in the horn 1 has the form indicated in Figure 3(a) for the 3<sup>rd</sup>-order resonance frequency  $3f_1$ , and has the form indicated in Figure 3(b) for the fundamental resonance frequency  $f_1$ .

A canceling speaker 5 is attached at a location  $(2/3) l$  from the main speaker 4 of the horn 1, and is driven with the same phase as the main speaker 4.

The sound pressure in the horn 1 generated by the canceling speaker 5 has the form indicated in Figure 3(c) for the 3<sup>rd</sup> order resonance frequency  $3f_1$ , and has the form indicated in Figure 3(d) for the fundamental resonance frequency  $f_1$ .

For this reason, the total sound pressure in the horn 1 has the form indicated in Figure 3(e) for the 3<sup>rd</sup> order resonance frequency  $3f_1$ , and has the form indicated in Figure 3(f) for the fundamental resonance frequency  $f_1$ . Resonance at the 3<sup>rd</sup> order resonance frequency  $3f_1$  is thus negated, but there is no attenuation at the fundamental resonance frequency  $f_1$ .

Another working example of the present invention is presented in Figure 4.

This working example is used in order to attenuate the 3<sup>rd</sup> order and 5<sup>th</sup> order resonance frequencies on the fundamental resonance frequency  $f_1$ .

The length of the horn 1 in this working example is 4 m, and the effective diameter of the opening 1a is 380 mm. The main speaker 4 and canceling speaker 5 have nominal diaphragm diameters of 180 mm, and the canceling speaker 5 is situated at a location that is half of the horn length  $l$ .

The function of this cancellation speaker 5 involves attenuation of the 3<sup>rd</sup> order and 5<sup>th</sup> order resonance frequencies, in contrast to attenuation of only the 3<sup>rd</sup> order resonance frequency  $3f_1$  in the previous working example.

Figure 7 compares the characteristics of the frequency sound pressure produced by the working example presented in Figure 5 with those of the horn-type speaker without a canceling speaker 5 presented in Figure 4. It is possible to attenuate the 70-130 Hz peaks in the working example, as indicated by B of Figure 7, relative to the characteristics of the horn speaker of Figure 5, as indicated by A.

Thus, the characteristics of the fundamental resonance frequency  $f_1$  in the 30-50 Hz vicinity are not changed.

Figure 6 is a working example for a cabinet-type device in which the horn 1 is a collapsible horn.

The cabinet height is 1295 mm, the width is 436 mm, the depth is 650 mm, and the board thickness is 18 mm.

The sound pressure frequency characteristics produced in this working example are indicated by C in Figure 7.

Based on these characteristics, it is clear that the 3<sup>rd</sup> order and 5<sup>th</sup> order resonance frequency peaks are attenuated by the canceling speaker 5, and that the level of the fundamental resonance frequency  $f_1$  is unchanged.

#### (Effect of the invention)

The present invention, as described above, involves attaching a canceling speaker at a location whereby the higher order resonance frequencies that are to be attenuated are in the opposite phase with respect to the sound pressure at the closed end of the horn, having a main speaker at its closed end. By driving the canceling speaker in the same phase as the main speaker, the peaks of the higher order frequencies are attenuated, without attenuating the sound pressure at the fundamental frequency.

Consequently, with horn-type speakers used for bass whereby the bass range is expanded, it is possible to attenuate peaks generated by higher harmonics, thereby generating a flat bass range and providing faithful reproduction.

#### 4. Brief description of the figures

Figure 1 is a cross-sectional diagram of a working example of the present invention.

Figure 2 is an internal sound pressure diagram of the 3<sup>rd</sup> order resonance frequency with respect to the fundamental resonance frequency in the horn.

Figure 3 is a sound pressure diagram that presents the relationship between the 3<sup>rd</sup> order resonance frequency and the fundamental resonance frequency.

Figure 4 is a cross-sectional diagram of another working example.

Figure 5 is a cross-sectional diagram of a conventional horn-type speaker that corresponds to the working example of Figure 4.

Figure 6 is a cross-sectional diagram of another working example.

Figure 7 is a graph of the sound pressure-frequency characteristics pertaining to Figures 4-6.

Figure 8 is a cross-sectional diagram of a conventional horn-type speaker.

Figure 9 is a graph of the sound pressure-frequency characteristics [of the horn-type speaker of Figure 8].

Figure 10 is a cross-sectional diagram of a conventional horn-type speaker in which higher-order resonance has been attenuated.

Figure 11 is a graph of the sound pressure-frequency characteristics [of the horn-type speaker of Figure 10].

- 1      Horn
- 4      Main speaker
- 5      Canceller speaker.

Figure 1

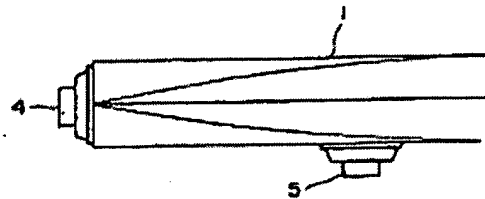
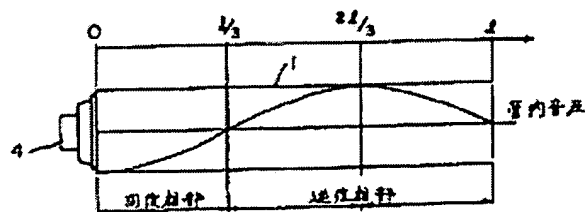


Figure 2



Sound pressure in tube

Same phase region

Reverse phase region

Figure 3

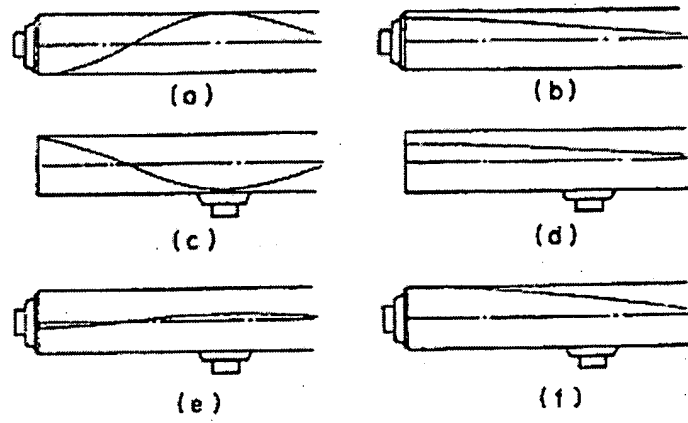


Figure 4

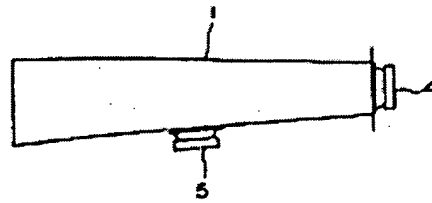


Figure 5

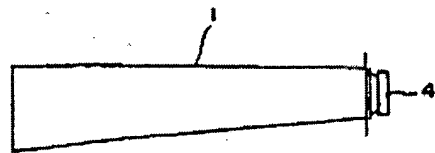


Figure 6

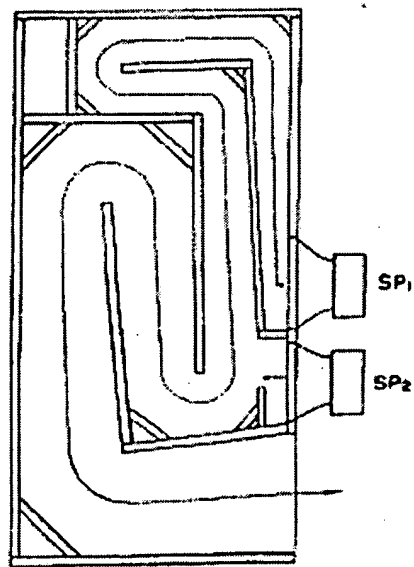
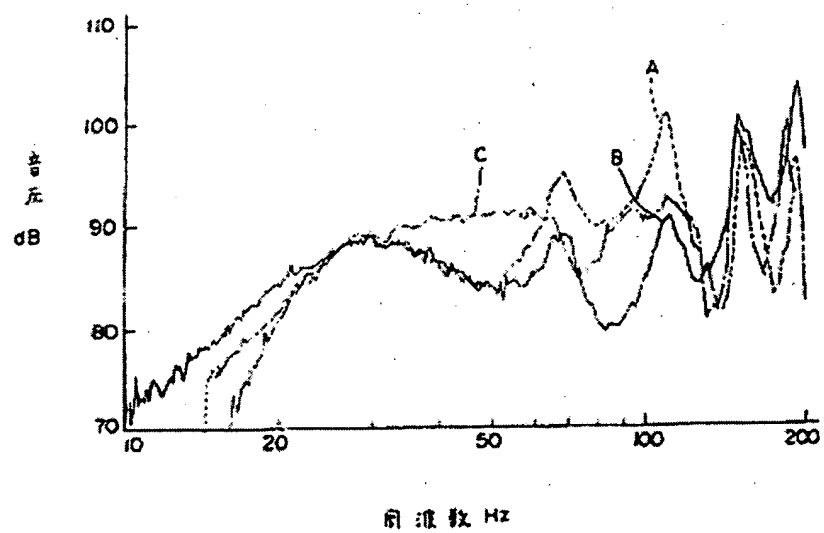


Figure 7



[horiz. axis:] Frequency Hz

[vert. axis:] Sound pressure dB

Figure 8

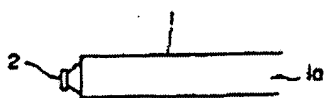
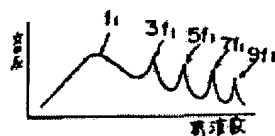


Figure 9



[horiz. axis] Sound pressure

[vert. axis.] Frequency

Figure 10

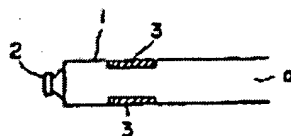


Figure 11



[horiz. axis] Sound pressure

[vert. axis.] Frequency